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Artificial Neural Networks for Modeling and Optimizing Egg Cost in Second-Cycle Laying Hens Based on Dietary Intakes of Essential Amino Acids

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Abstract: Egg production is a significant source of animal protein for human consumption. Feed costs significantly impact the profitability of egg production, representing more than 70% of the variable costs. This study evaluated the effect of dietary intakes of three essential amino acids (EAAs) on the egg cost for H&N Brown second-cycle laying hens. The hens were fed for 20 weeks with 23 diets that varied in their lysine, methionine + cystine, and threonine contents. These amino acids were derived from both dietary and synthetic sources. Zootechnical results were used to calculate the feed cost per kilogram of egg (FCK), considering the cost of raw materials and the diet composition. Multivariate polynomial models and artificial neural networks (ANNs) were validated to predict FCK as a function of the EAAs and time. The EAA intakes that minimize FCK over time were optimized using the best model, a cascade-forward ANN with a softmax transfer function. The optimal scenario for FCK (0.873 USD/kg egg) at 20 weeks was achieved at 943.7 mg lysine/hen-day, 858.3 mg methionine + cystine/hen-day, and 876.8 mg threonine/hen-day. ANNs could be a valuable tool for predicting the egg cost of laying hens based on the nutritional requirements. This could help improve economic efficiency and reduce the feed costs in poultry companies.

Keywords: animal nutrition; egg laying; feed costs; mathematical model; multivariate analysis; poultry

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1. Introduction

According to FAO estimations, the world population may increase to 9.8 billion by 2050 [1]. This accelerated growth has aroused worldwide concern, mainly due to the difficulty of producing more food without affecting food security and of making it accessible to the entire population. Among the possible strategies that can be implemented to increase food production worldwide, egg production is emerging as a viable alternative to advance progress toward the second Sustainable Development Goal (end hunger, achieve food security and improved nutrition, and promote sustainable agriculture) [2].

From a nutritional point of view, eggs are an essential source of proteins, phospholipids, vitamins (e.g., thiamin, riboflavin, niacin, vitamin B12, vitamin A, vitamin E, vitamin D, and vitamin K), minerals (e.g., iron, selenium, calcium, magnesium, phosphorus, potassium, sodium, and zinc) and antioxidants, and their consumption could cover part of the daily needs of these types of nutrients [3,4]. Furthermore, this product presents advantages over other protein sources, primarily stemming from its low commercial cost, which has increased its consumption and production worldwide. It is estimated that between 2018 and 2020, egg production increased by more than 8% worldwide [5]. Despite the growth of this industry and the egg's nutritional value, some factors limit its production, such as costs associated with animal feed, which can exceed 70% of variable costs [6]. An effective strategy to reduce egg production costs is the implementation of second production cycles in birds. By adopting this method, different benefits are obtained, such as increased laying cycles and egg size, which provide responsiveness to fluctuations in costs associated